(12) UK Patent Application (19) GB (11) 2 343 173 (13) A

(43) Date of Printing by UK Office 03.05.2000

(21) Application No 0000459.8

(22) Date of Filing 15.07.1998

(30) Priority Data
(31) 09189502 (32) 15.07.1997 (33) JP

(86) International Application Data
PCT/JP98/03182 Jp 15.07.1998

(87) International Publication Data
WO99/04104 Jp 28.01.1999

(51) INT CL[7]
E02F 3/38 , B23K 37/04

(52) UK CL (Edition R)
B8H HFB H403 H430 H551
B3A A137
U1S S1762

(56) Documents Cited by ISA
JP 620137327 Y JP 090165773 Y

(58) Field of Search by ISA
INT CL[7] E02F 3/38
Int.Cl7 E02F3/38

(71) Applicant(s)
Komatsu Limited
(Incorporated in Japan)
3-6 Akasaka 2-chome, Minato-ku, Tokyo 107, Japan

(72) Inventor(s)
Hidetoshi Sasaki
Toshio Tanaka
Tatsushi Itoh
Nobuyoshi Masumoto

(74) Agent and/or Address for Service
fJ Cleveland
40-43 Chancery Lane, LONDON, WC2A 1JQ,
United Kingdom

(54) Abstract Title
Structure for working unit for bucket excavators and method for manufacturing the same

(57) A bucket connecting bracket (23) is connected to one longitudinal end of a hollow arm body (22) having a triangular cross section, and a boom mounting bracket (26) is connected to the longitudinal middle part of the arm body (22) while an arm cylinder bracket (24) is connected to the other longitudinal end of the arm body (22) to constitute an arm. As a result, the arm body (22) is made resistant to deformation in cross section, so that its plate thickness can be reduced and its rigidity is enhanced without resort to a cross section bracing member, thereby manufacturing a light-weight arm free from cross-sectional deformation.

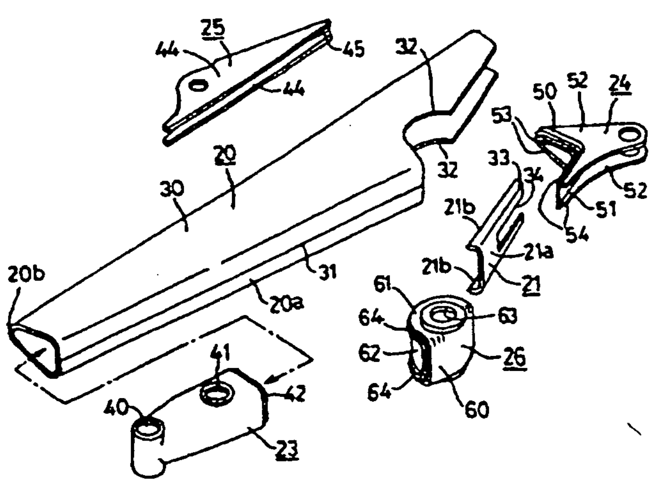

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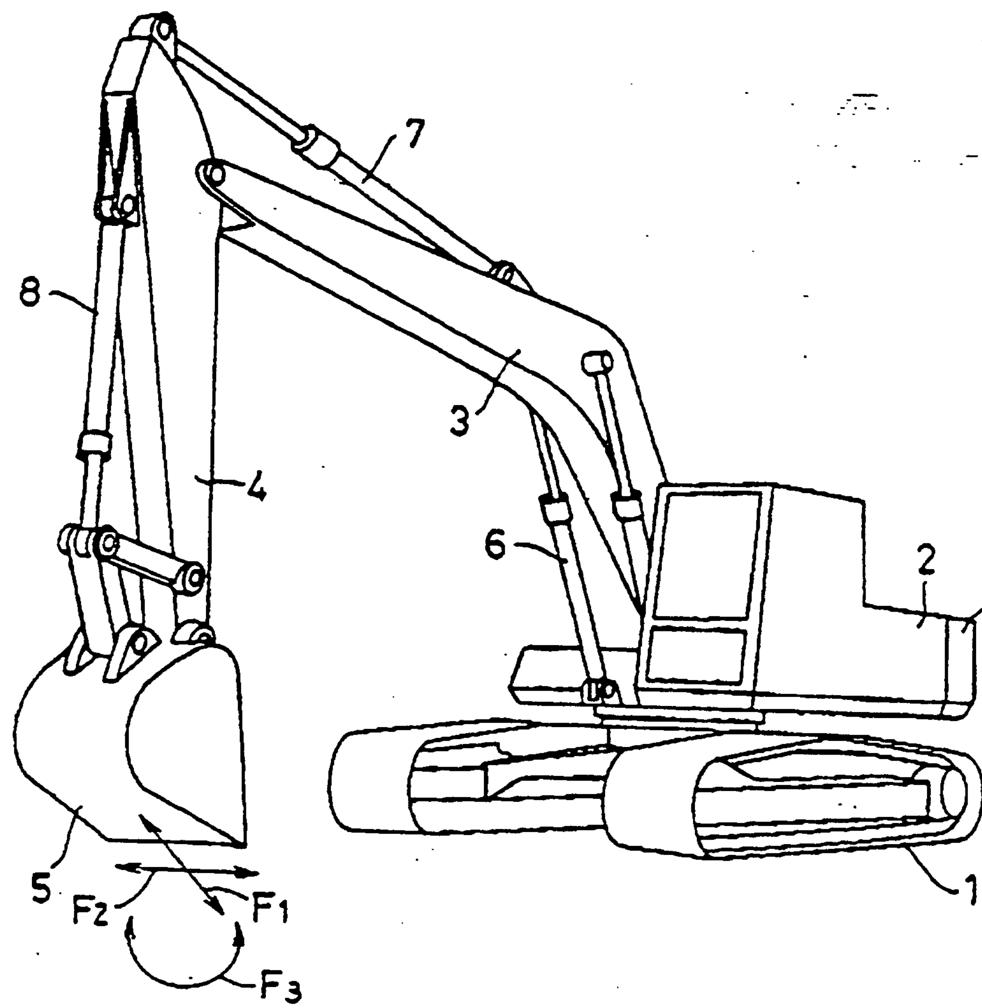
FIG 1



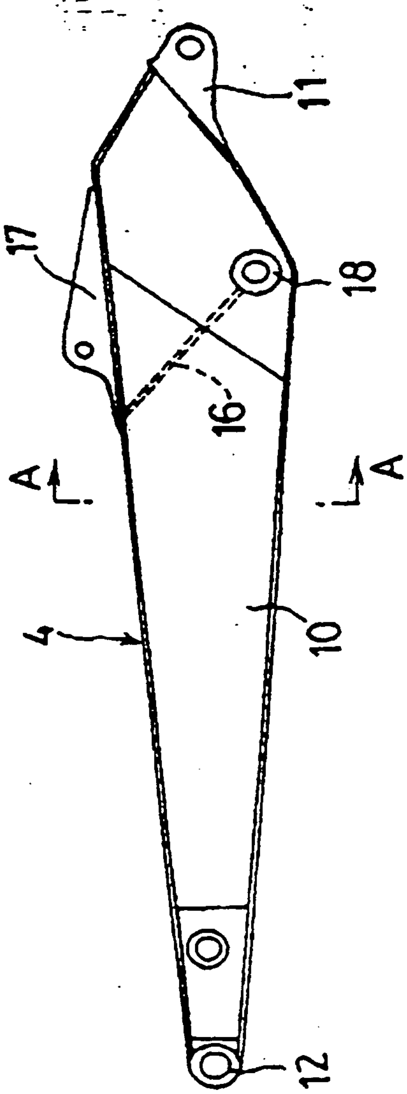


FIG 2

FIG 3

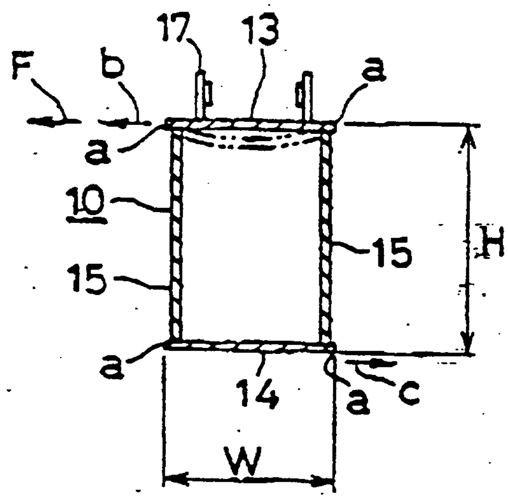
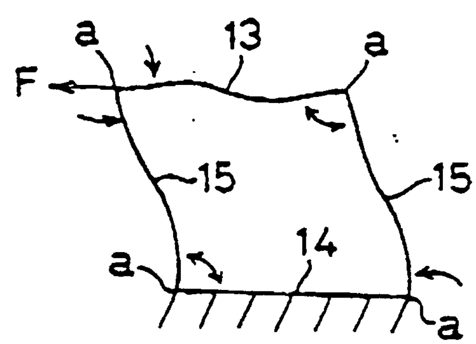


図 4



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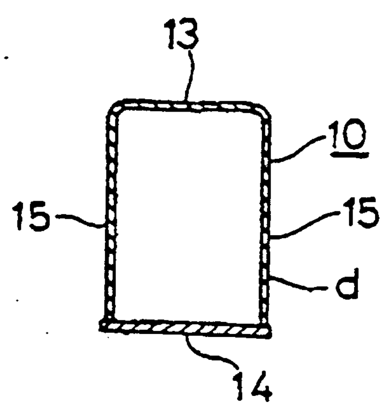

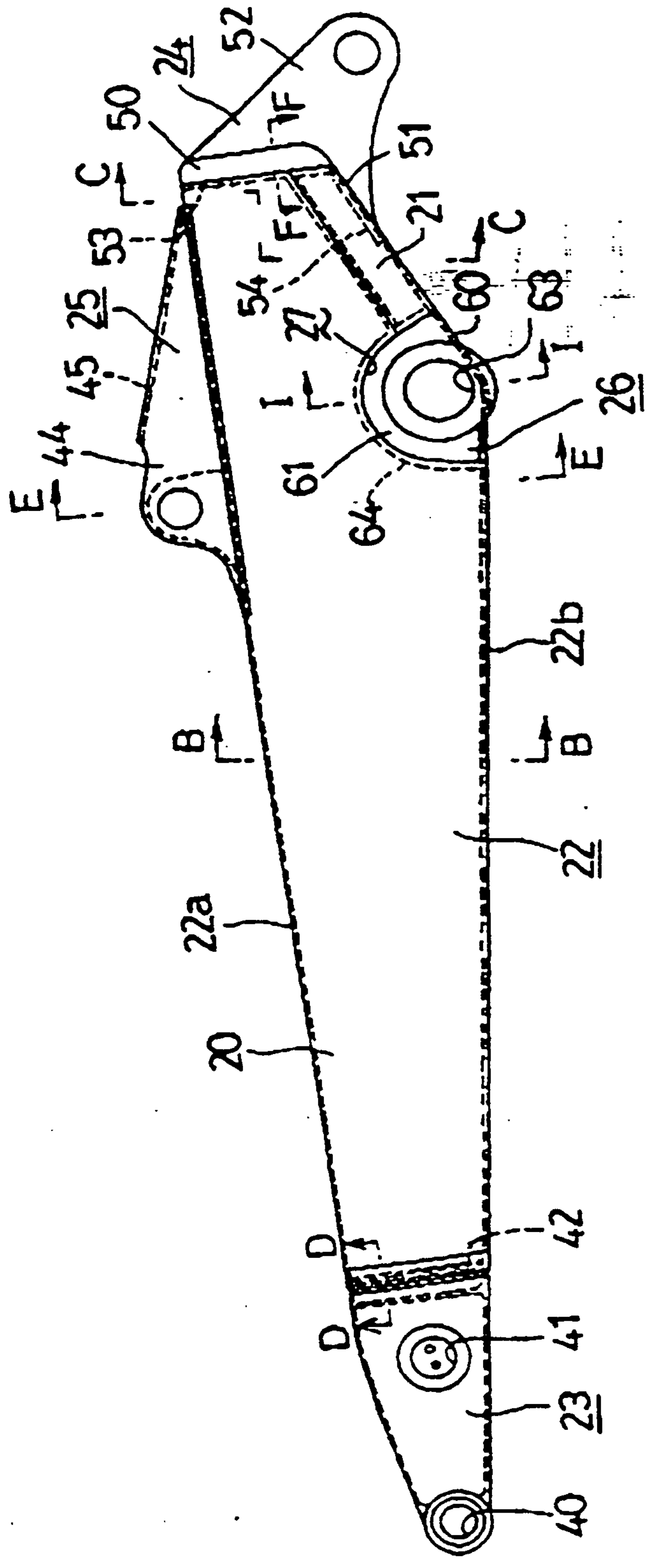

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24
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C
F
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53
21
F
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27
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C
45
I
I
26
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E
64
22b
B
B
22a
22
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D
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D
41
23
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FIG 6

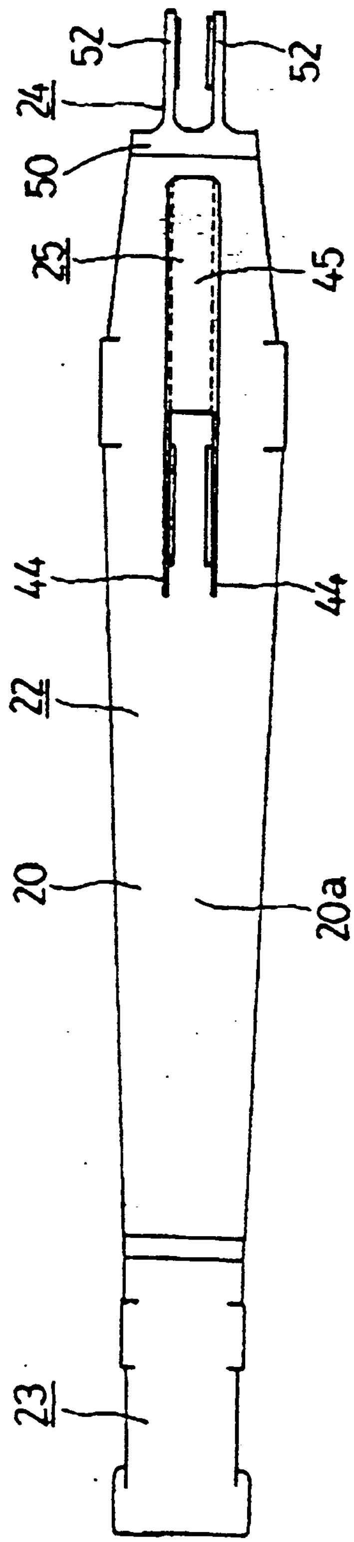
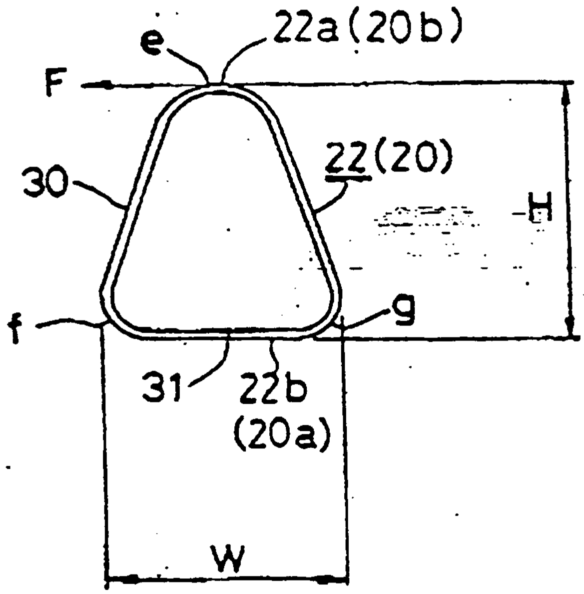


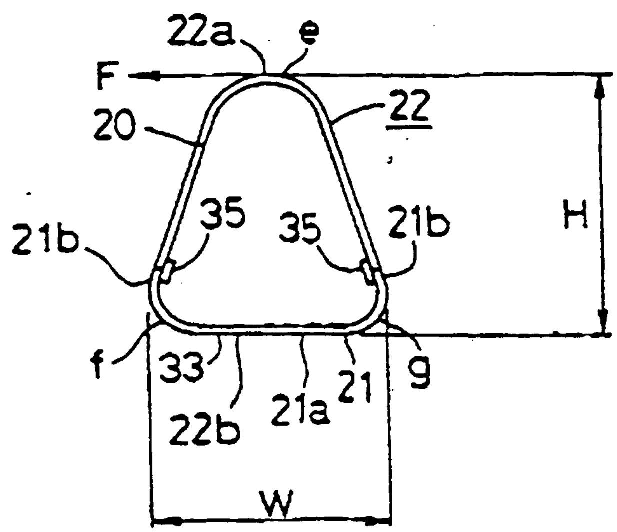
FIG 7

FIG 8



e
22a (20b)
F
22(20)
30
H
f
g
31
22b
(20a)
W

FIG 9



22a
e
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21
g
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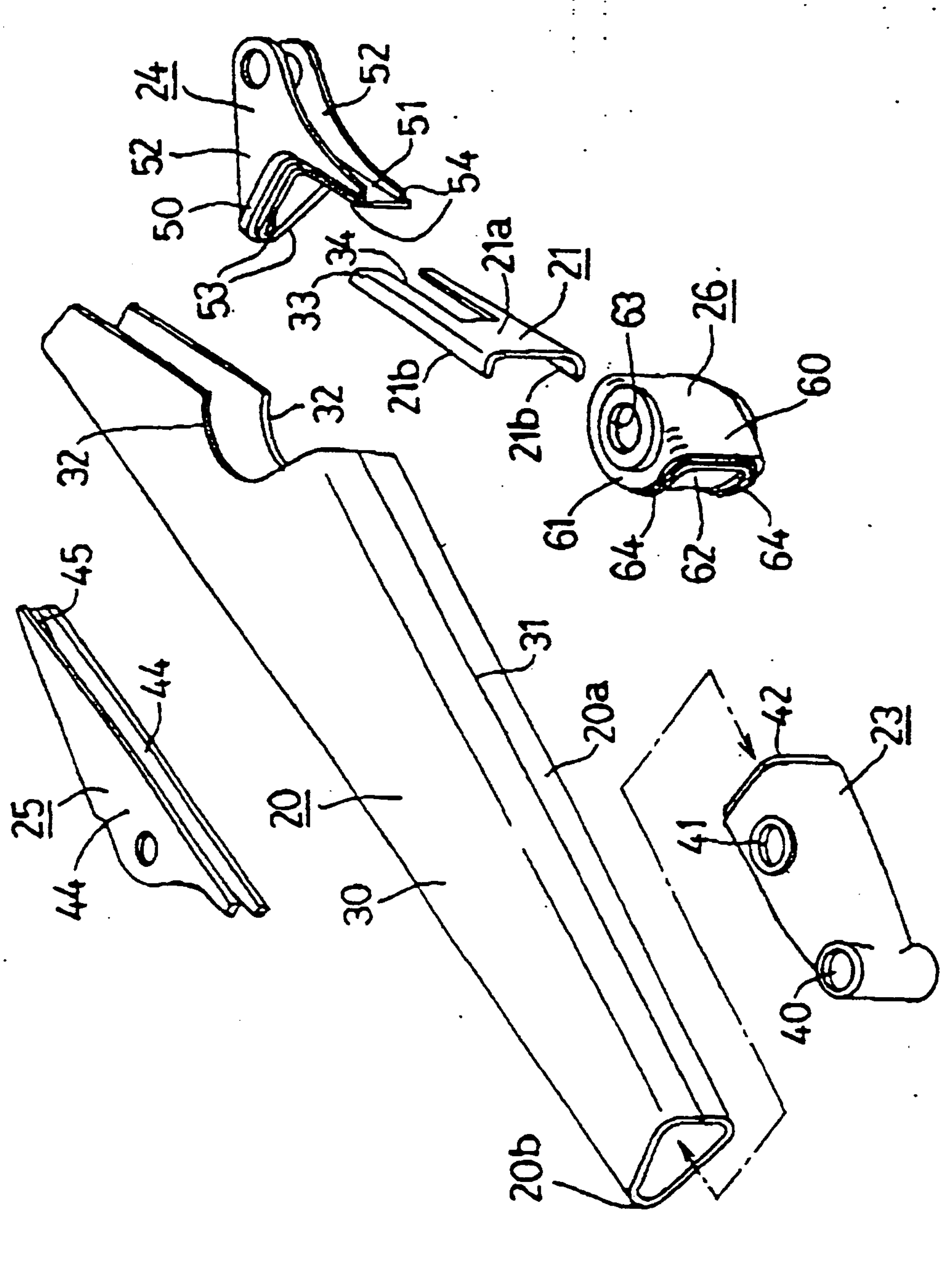
FIG 10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21a
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21b
21b
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20a
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23
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20b

FIG 11

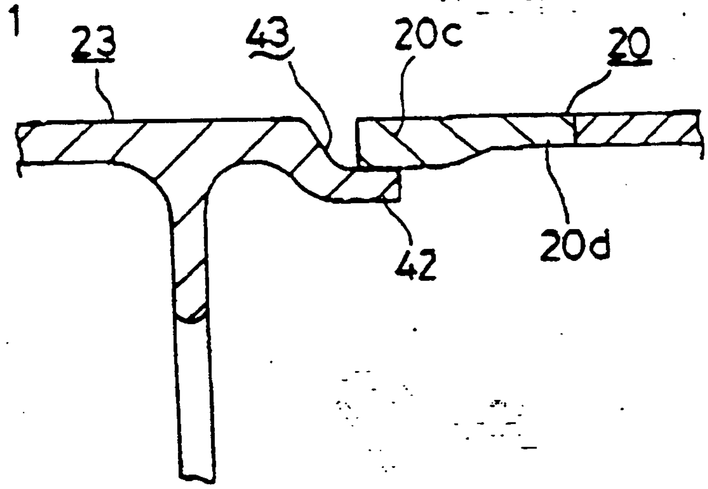
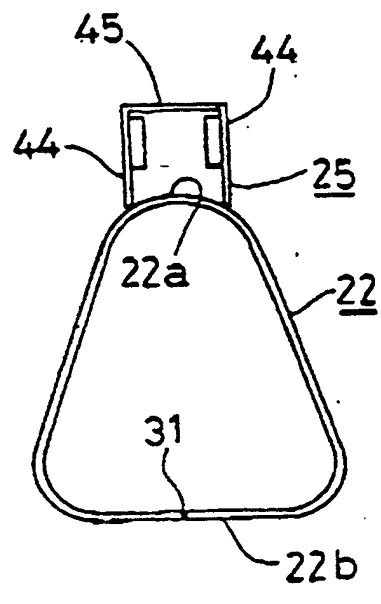


FIG 12



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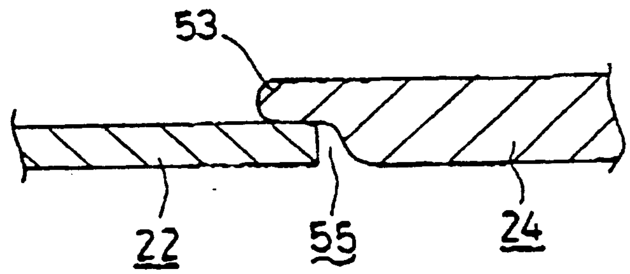

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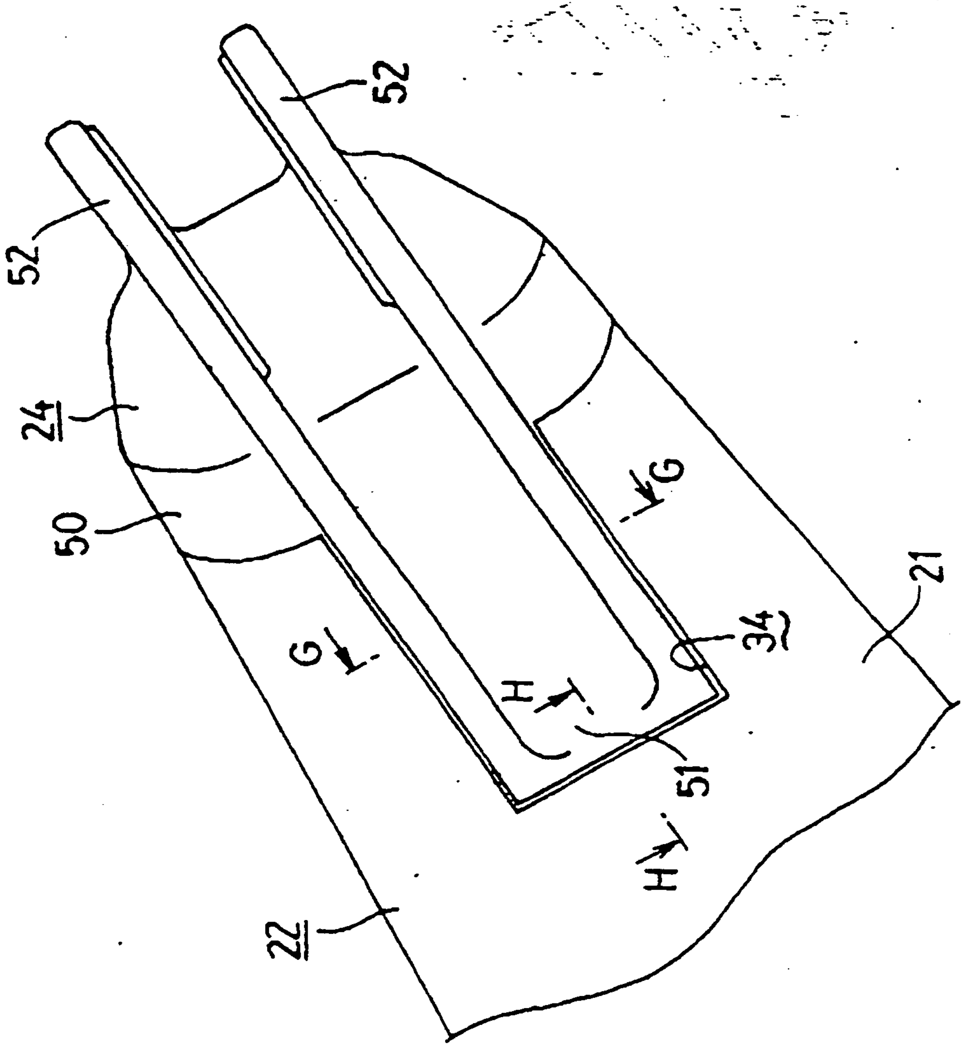

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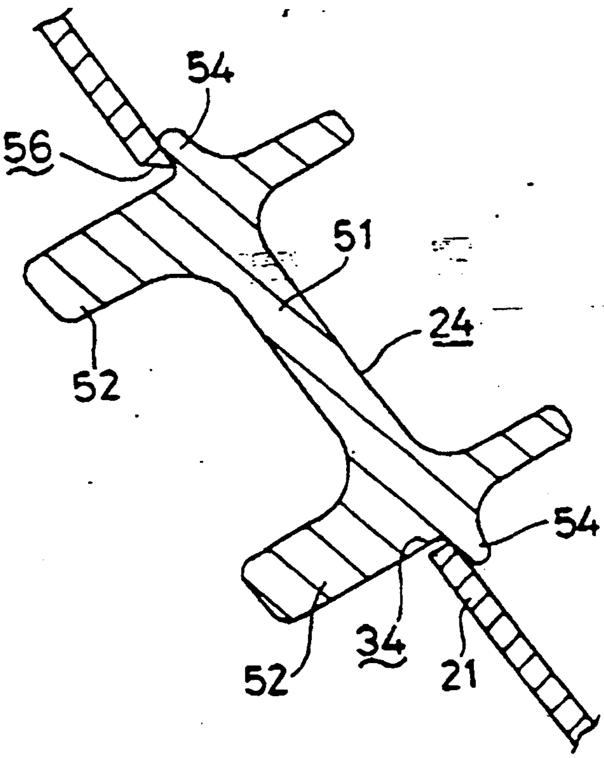
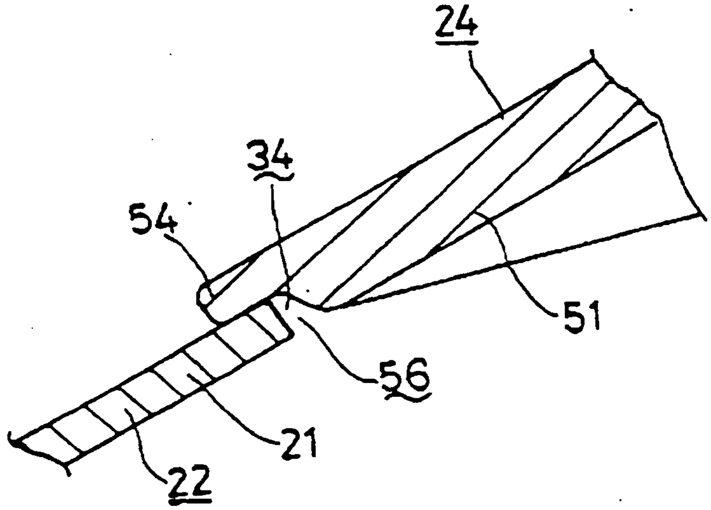


FIG 16



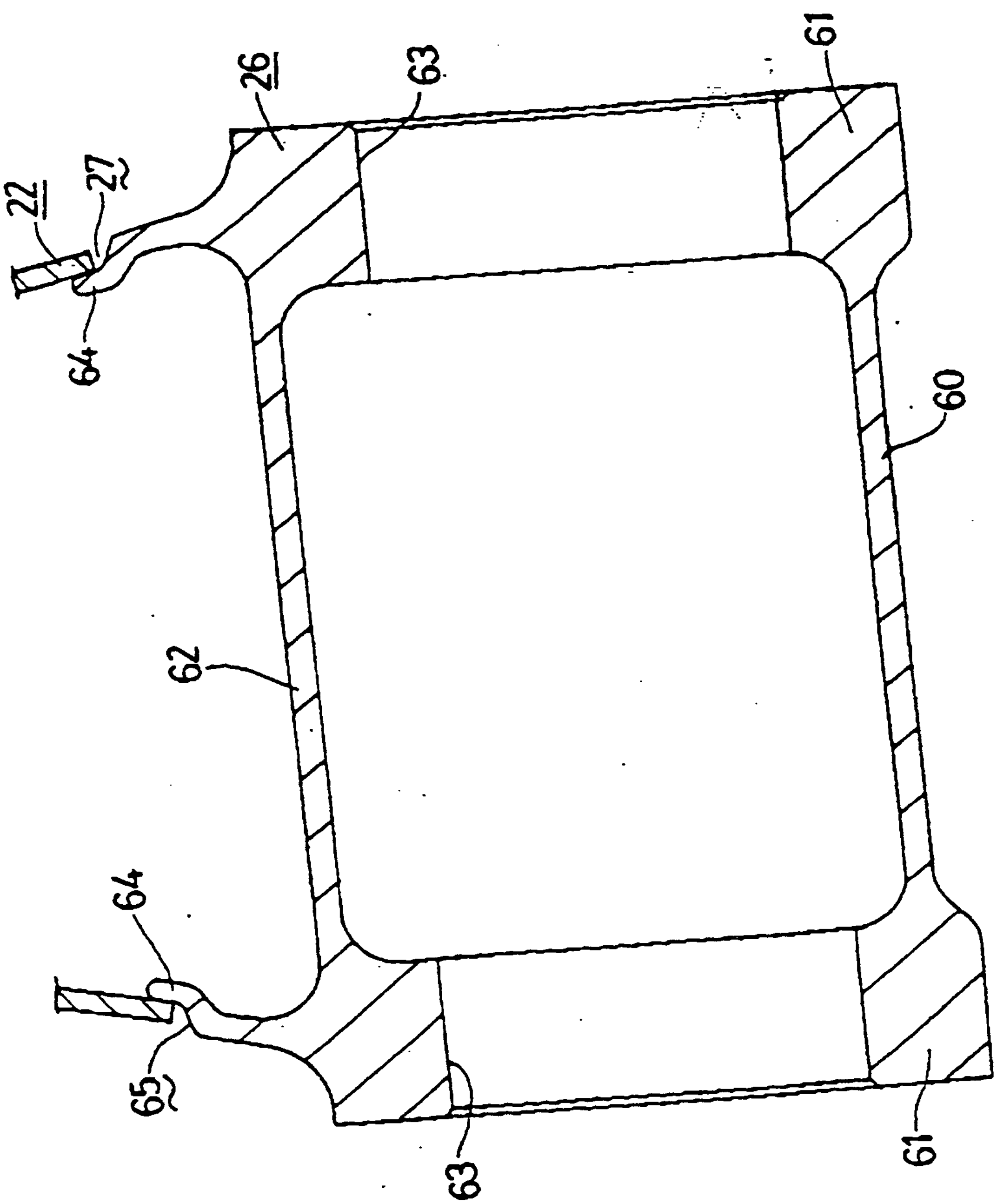


FIG 17

FIG 18

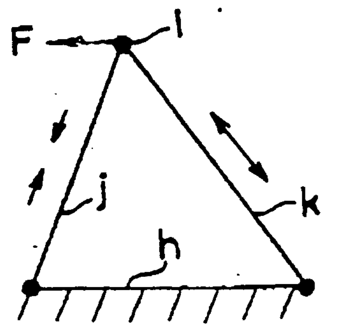


FIG 19

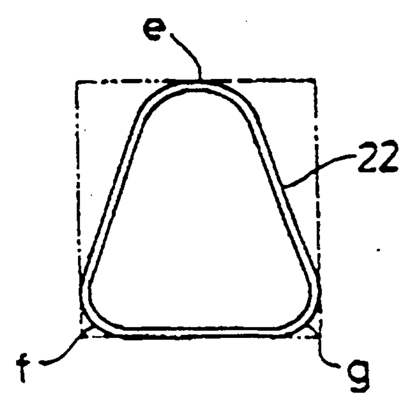
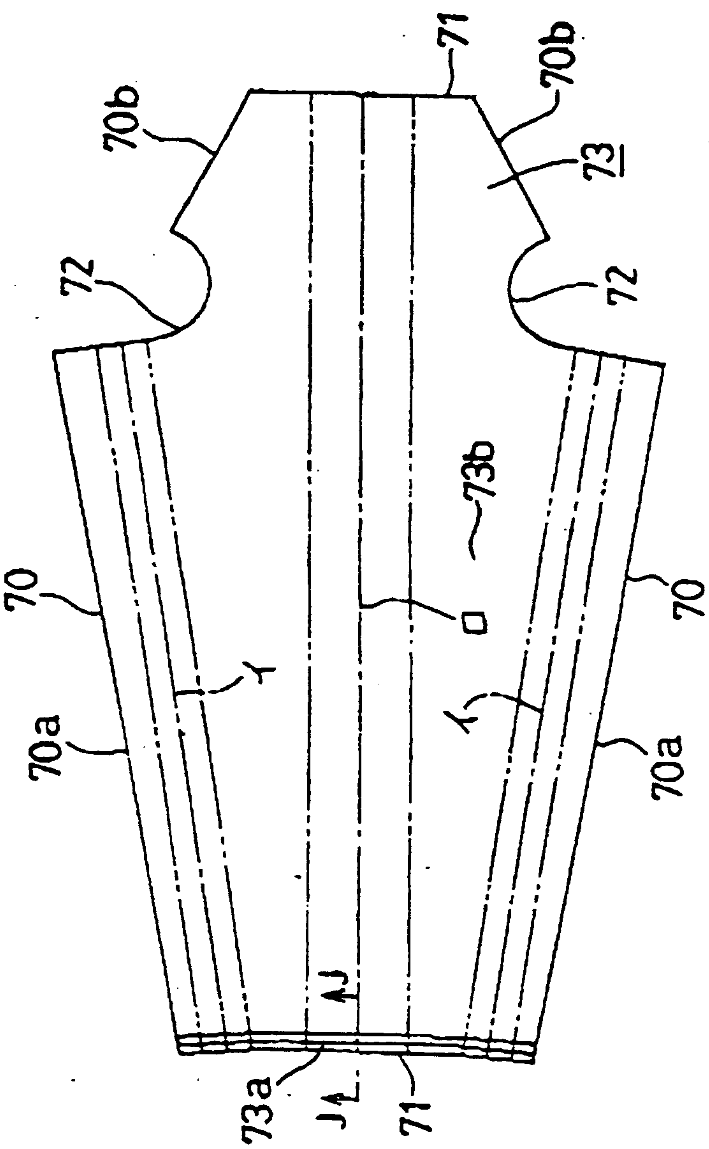


FIG 20



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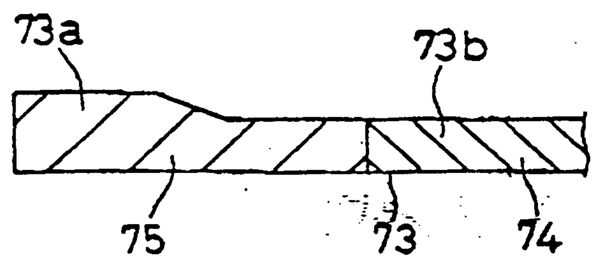

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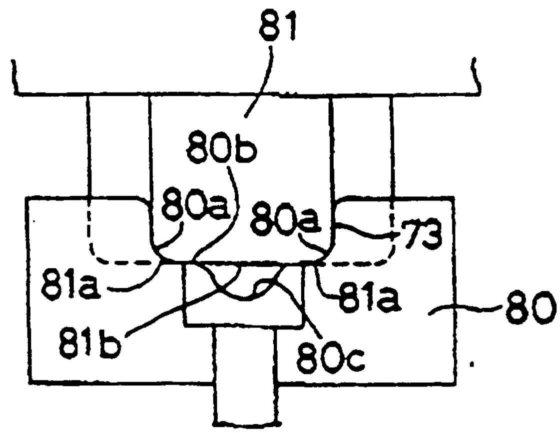

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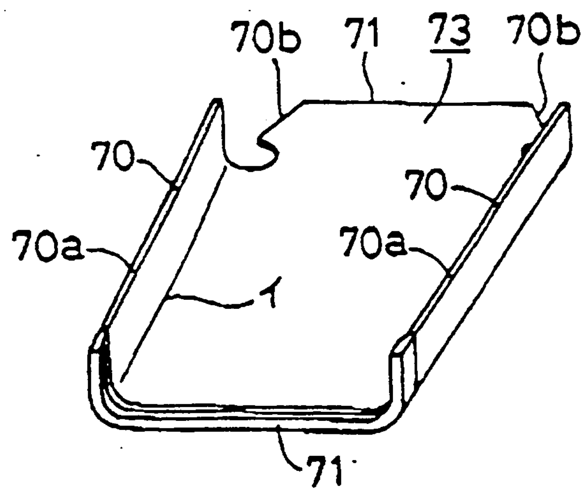

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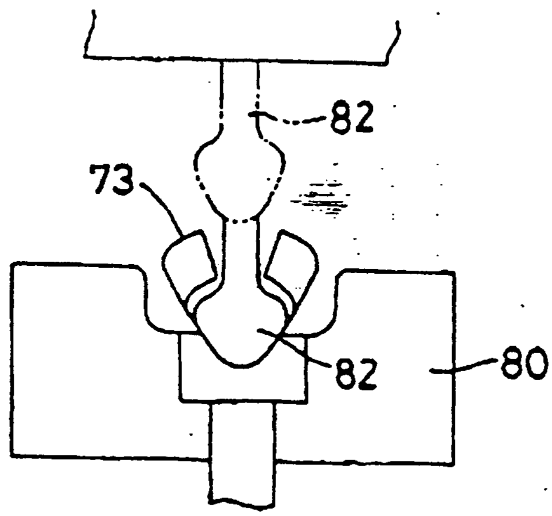

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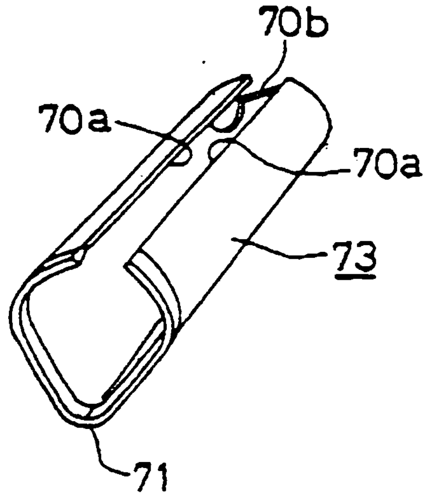
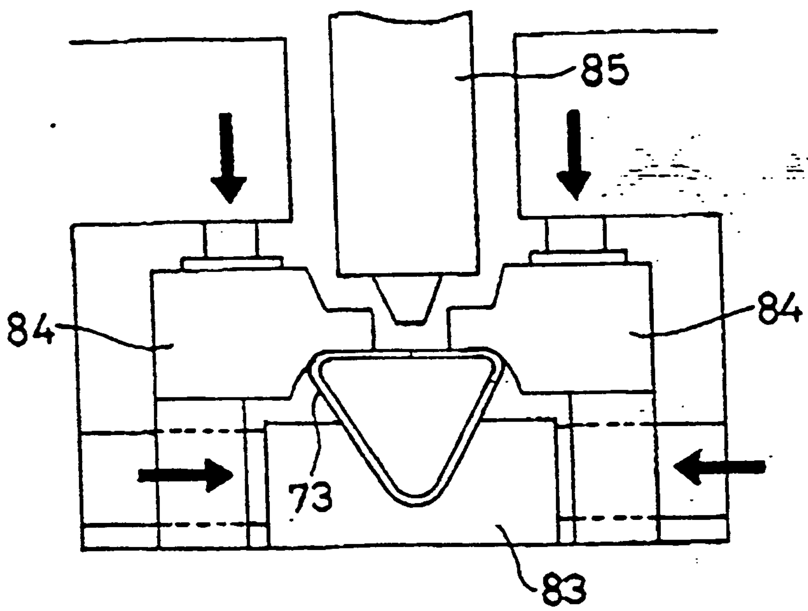


FIG 26



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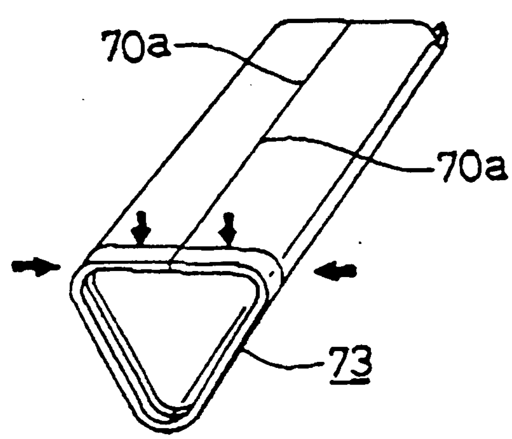
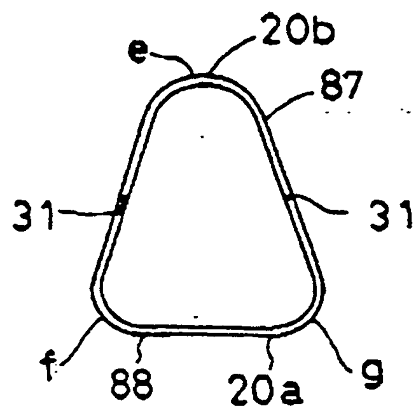


Fig 28

(a)



(b)

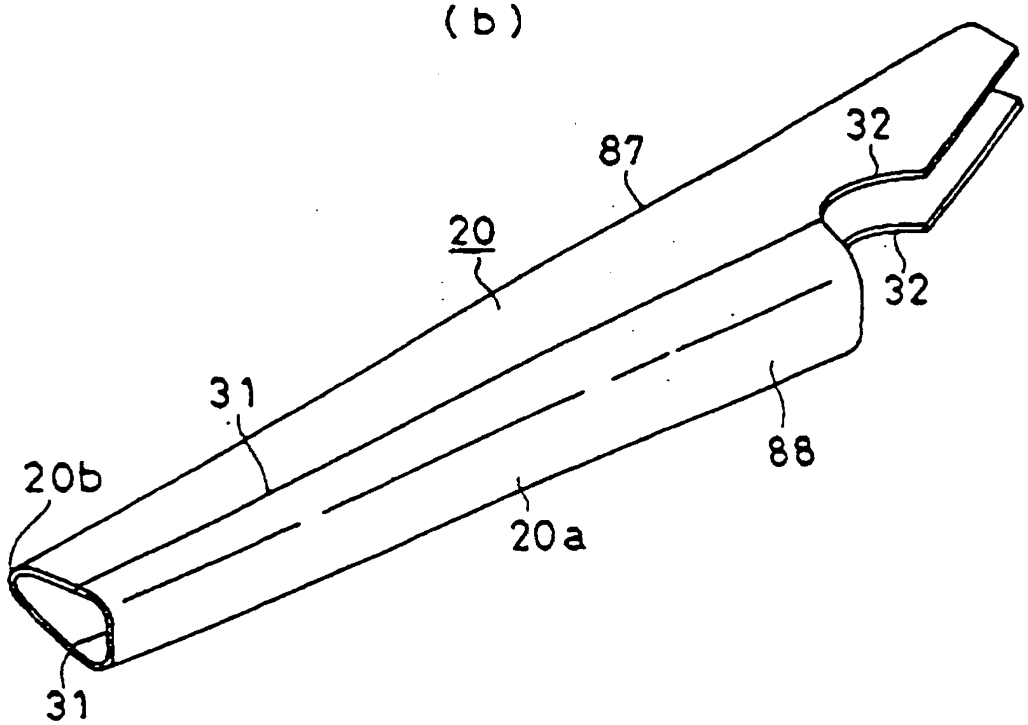
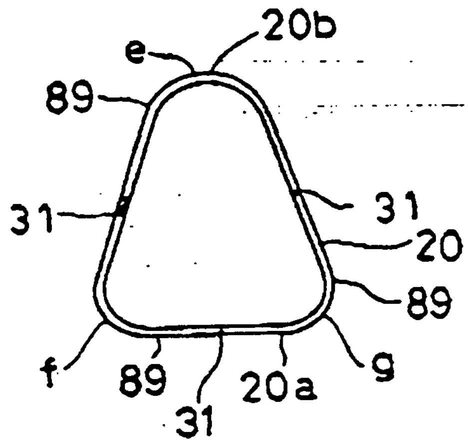


FIG 29

(a)



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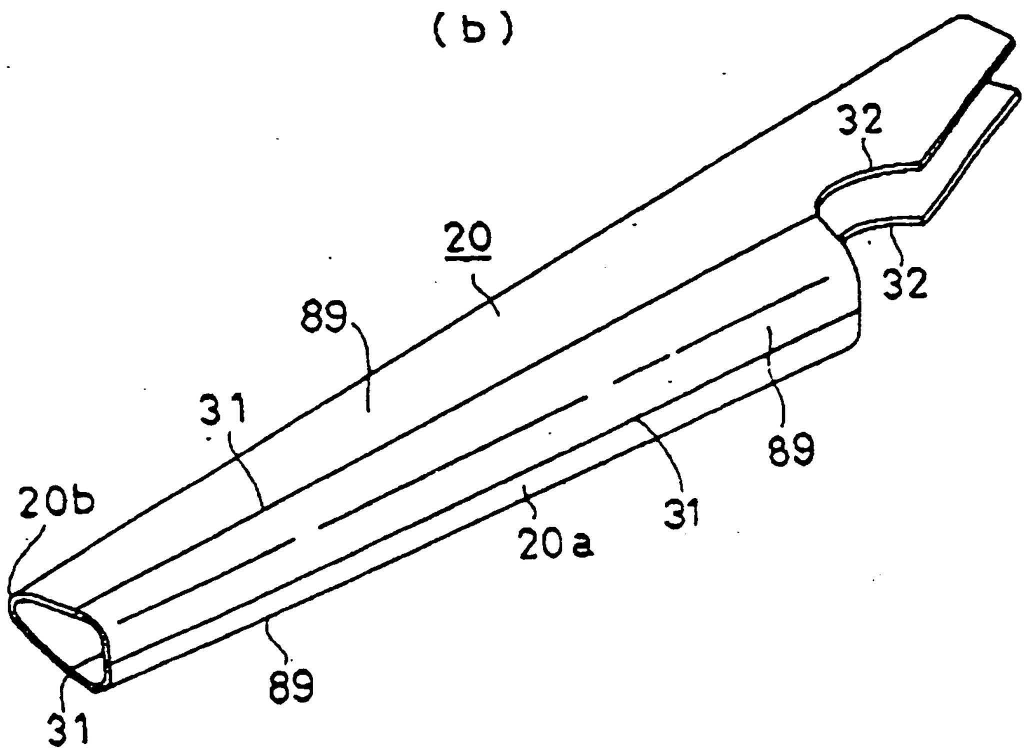
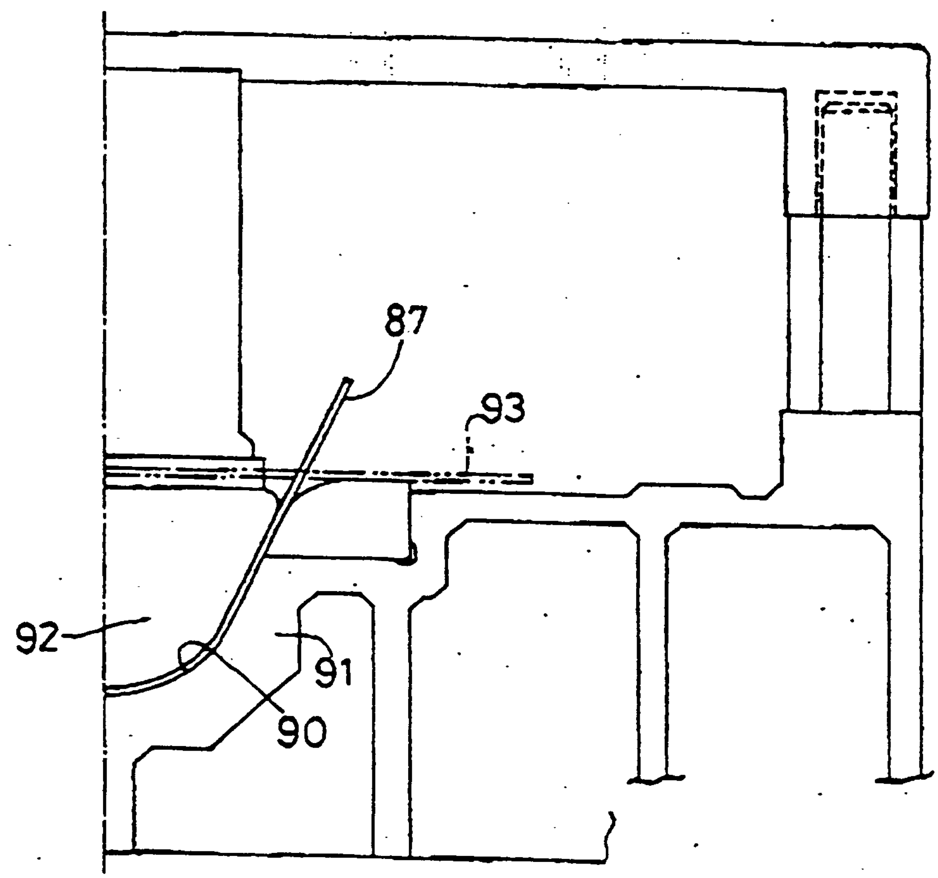


FIG 30



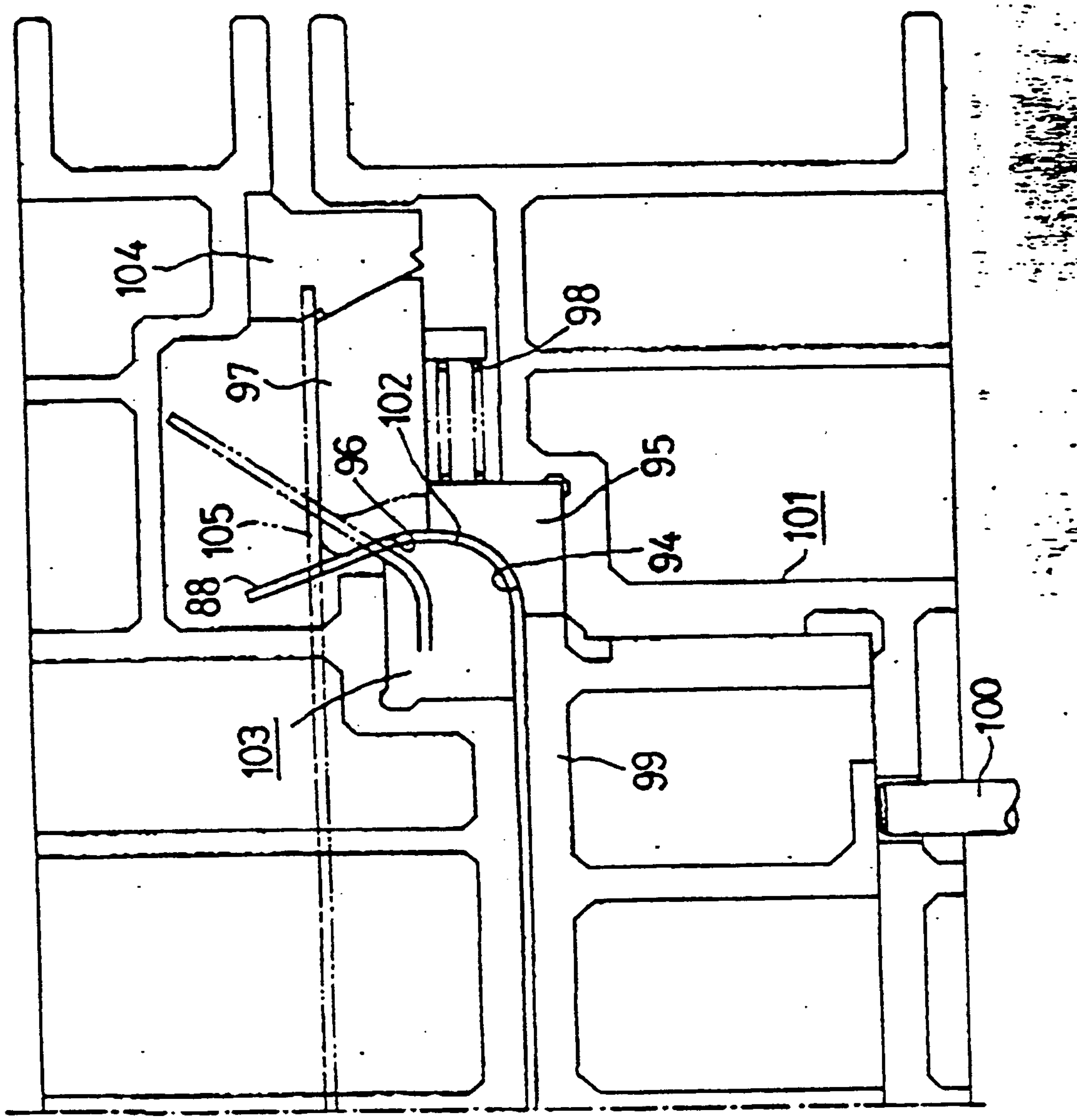


FIG 31

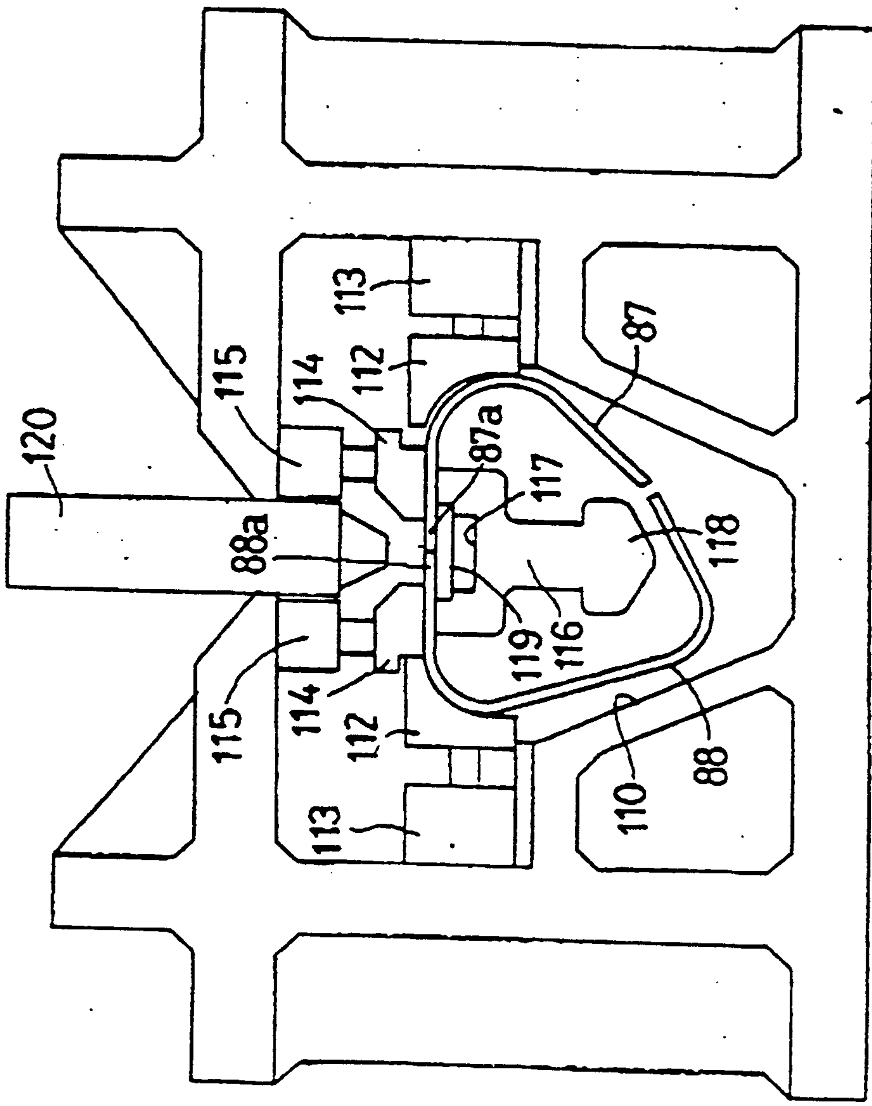

120
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FIG 32

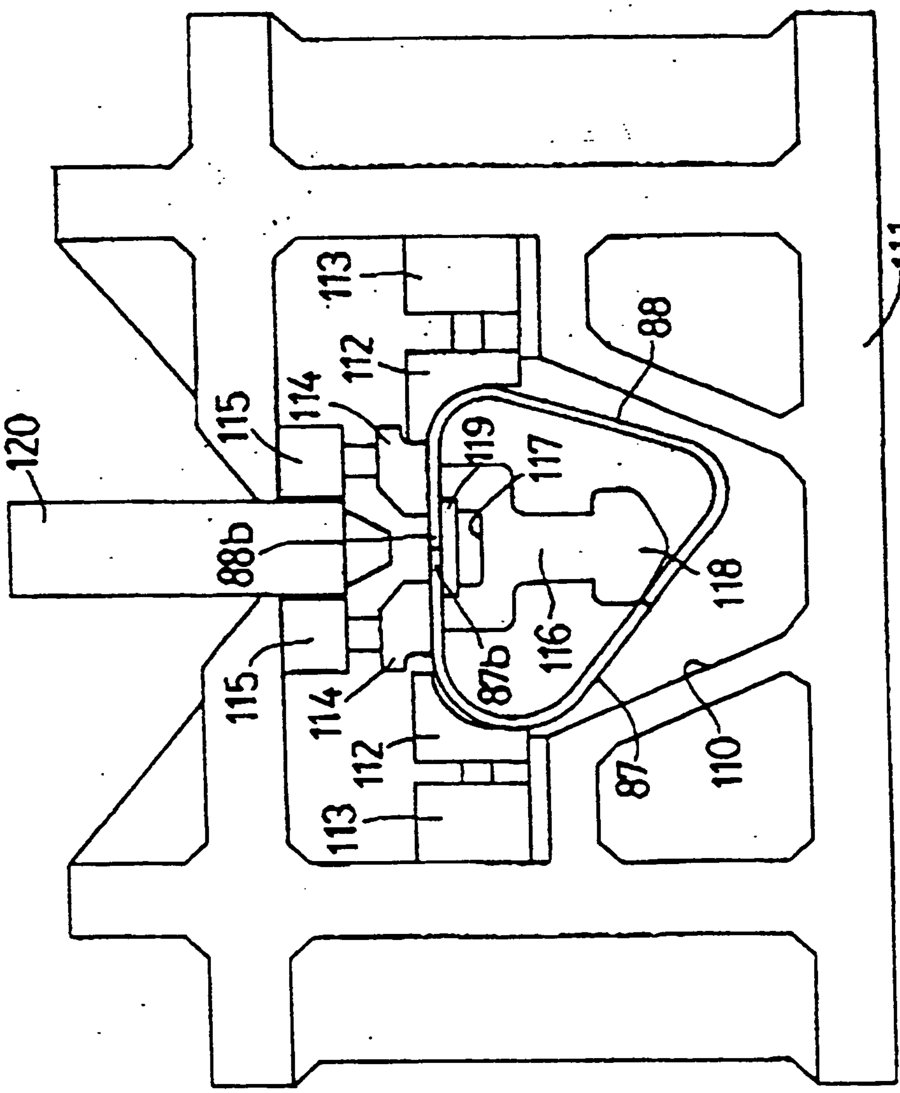


FIG 33

FIG 34

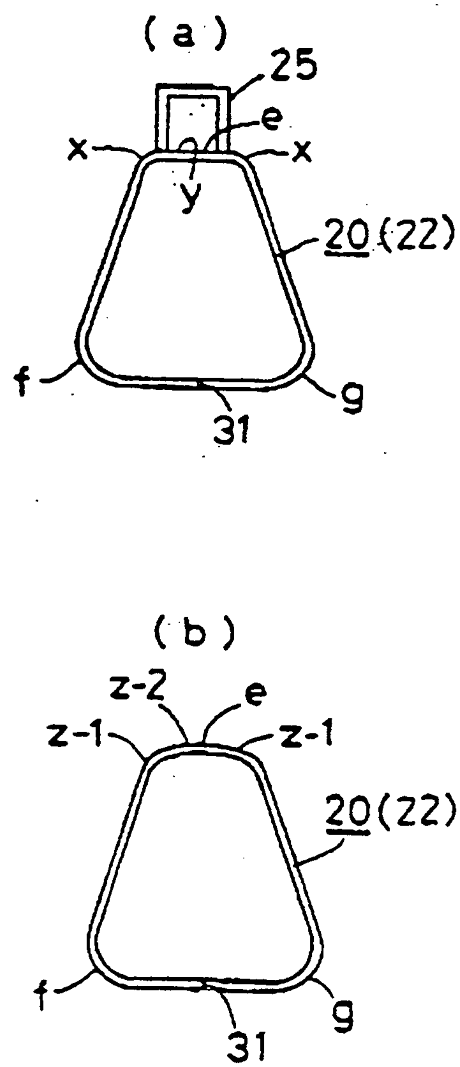
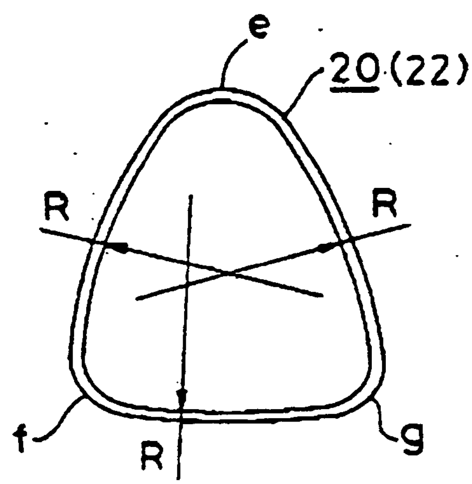


FIG 35



SPECIFICATION

STRUCTURE FOR WORKING MACHINE OF BUCKET TYPE EXCAVATOR AND PRODUCING METHOD THEREOF

TECHNICAL FIELD

The present invention relates to a structure for a working machine of a bucket type excavator such as a hydraulic shovel, and a producing method of an arm of the bucket type excavator and the structure for the working machine of the bucket type excavator.

BACKGROUND TECHNIQUE

As shown in Fig.1, in a hydraulic shovel which is a kind of a bucket type excavator, an upper vehicle body 2 is turnably mounted on a lower running body 1, a boom 3 is vertically swingably mounted to the upper vehicle body 2, an arm 4 is vertically oscillatably mounted to the boom 3, and a bucket 5 is vertically oscillatably mounted to a tip end of the arm 4. A boom cylinder 6 is connected between the upper vehicle body 2 and the boom 3, an arm cylinder 7 is connected between the boom 3 and the arm 4, and a bucket cylinder 8 is connected between the arm 4 and the bucket 5.

The hydraulic shovel vertically swings the boom 3, the arm 4 and vertically oscillates the bucket 5, and at the same time, laterally turns the upper vehicle body 2, thereby carrying out operations such as excavation and loading to a dump truck.

As shown in Fig.2, the arm 4 comprises an arm body 10, an arm cylinder-mounting bracket 11 jointed to longitudinally one end of the arm body 10, and a bucket-connection bracket 12 jointed to longitudinally other end of the arm body 10. As shown in Fig.3, the arm body 10 is hollow and rectangular in cross section comprising an upper lateral plate 13, a lower lateral plate 14 and left and right vertical plates 15, 15.

As shown in Fig.1, at the time of operation, a vertical load F1, a lateral load F2, a torsion load F3 and the like are applied to the arm 4, and durability against these loads is secure.

For example, against the vertical load F1, a width W and a height H as well as plate thickness of each of the upper lateral plate 13, the lower lateral plate 14 and the left and right vertical plates 15, 15 are appropriately set in accordance with magnitude of the loads as shown in Fig.3. In addition to these, against the lateral load F2 and the torsion load F3, a cross section restraint member

such as a rib 16 shown in Fig.2 is added.

In the hydraulic shovel, a counter weight 9 is provided at a rear portion of the upper vehicle body 2 in accordance with the excavation ability of a working machine comprising the upper vehicle body 2 which is a main portion, the boom 3, the arm 4 and the bucket 5. If the working machine is reduced in weight, the weight of the counter weight 9 mounted to the rear portion of the upper vehicle body 2 can be reduced, the rearward projecting amount of the upper vehicle body 2 can be reduced and therefore, a turning radius of the rear end of the upper vehicle body 2 can be reduced.

If the working machine comprising the boom 3, the arm 4 and the bucket 5 is reduced in weight, it is possible to increase the volume of the bucket correspondingly instead of reducing the weight of the counter weight 9 and thus to increase the working amount.

Further, the arm 4 is vertically swung by the arm cylinder 7, and a portion of a thrust of the arm cylinder 7 supports the weight of the arm 4. Therefore, if the arm 4 is reduced in weight, the thrust of the arm cylinder 7 can effectively utilized as the vertical swinging force of the arm 4. Similarly, the weight of the arm 4 itself is applied to the boom cylinder 6, if the arm 4 is reduced in weight, thrust of the boom cylinder 6 can effectively be utilized.

In generally, when considering a strength of the working machine of the bucket type excavator, as the simplest method, a working machine is replaced with a beam or a thin pipe which is discussed in material mechanics and a strength with respect to the bending and torsion can be evaluated.

That is, bending stress σ, and shearing stress τ generating on a cross section can be obtained by the following general formulas (1) and (2):

(1) $\sigma=M/Z$

(wherein, σ: bending stress generating on a cross section, M: bending moment applied to the cross section, Z: cross section coefficient)

(2) $\tau=T/2At$

(wherein, τ: shearing stress, T: torsion torque, A: projection area of neutral line of cross section plate thickness, t: thickness of cross section plate)

An appropriate shape of the cross section can be determined from the results of the above calculation and permissible stress of the material to be used. Similarly,

deflection of the beam and torsion of the axis can be calculated using general formula of the material mechanics, and such calculation, rigidity of the working machine can also be evaluated.

However, if a working machine designed in accordance with the above evaluation method is actually produced and stress test is carried out, the result of the test is different from a stress value calculated during the evaluation in many cases. For this reason, in recent years, simulation by a computer using finite element method (FEM) is used as the evaluation method for enhancing the precision of the stress evaluation. If the stress is calculated using the FEM simulation, it can be found that a cross section of a working machine which was considered as beam and axis of material mechanics is changed in shape before and after the load is applied. From this fact, it can be understood that a stress calculated using the general formulas of the material mechanics derived based on a presumption that a shape of a cross section is not changed and a stress measured when a stress test is actually carried out do not coincide with each other.

In the case of a conventionally used working machine having a rectangular cross section, there are two factors for determining a deformation strength of the cross section, i.e., rigidity of a rectangular angle portion and rigidity of a rectangular side portion in the outward direction of a surface. When each of the two rigidity does not have sufficient strength against a load, the cross section is deformed as shown in Fig.5, and an excessive load is applied to the rectangular angle portion. To prevent those, a cross section restraint material such as a partition wall is required for a portion in which its cross section is deformed, but if such material is provided, productivity of the working machine is lowered.

If the above facts are applied to the arm 4, the arm 4 is of hollow shape of rectangular cross section as shown in Fig.3, rigidity of the cross section is determined by bending rigidity of an angle portion a, bending rigidity (rigidity in the outward direction of surfaces) of the four surfaces (the upper lateral plate 13, the lower lateral plate 14, and the left and right vertical plates 15 and 15).

That is, influence of the bending rigidity of the surfaces and the bending rigidity of the angle portion is great with respect to the deformation of the cross

section. For example, in Fig.3, when the lower plate 14 is fixed, and a load F shown with the arrow F is applied, as shown in Fig.4 schematically, each of the angle portions a is bent and deformed, the upper plate 13 and the left and right vertical plates 15 and 15 are bent and deformed in the outward direction of the surfaces (thickness direction). When the thickness of the plate is reduced, reduction of rigidity in the outward direction of the surface is proportional to the third power of a ratio of reduction of the plate thickness.

For these reasons, if the thickness of each plates is reduced to increase the cross section, when the lateral load F2 and the torsion load F3 are applied to the arm 4, a deformation is generated in the lightweighted boom 3 as shown with the arrows b and c in Fig.3, the rigidity of the entire boom is largely lowered. Therefore, the above-described cross section restraint material such as the partition wall 16 and the pipe 17 must be reinforced, the weight of the boom is increased because of the reinforced cross section restraint material, the structure is complicated because of the partition wall 16 and the pipe 17, and there is a problem with the productivity due to increase in welding portions.

Further, as shown in Fig.2, the arm 4 is provided with a bucket cylinder bracket 17 for connecting the bucket cylinder 8 and a boom cylinder-connection boss 18 for connecting the boom 3. If the thickness of each of portions to which these are to be connected, e.g., the left and right vertical plates 15, 15 and the upper lateral plate 13 is reduced, the rigidity in the outward direction of the surface is lowered. Therefore, in some cases, this further increases the deformation in the outward direction of the surface and reduces the rigidity of the arm 4, and a deformation shown with a phantom line in Fig.3 is generated. Thus, it is difficult to reduce the thickness of plate material forming the arm body 10.

Further, since the plate members forming the arm body 10 are welded to one another at right angles, if the thickness of the plate members is reduced, the weld jointing efficient is lowered, and it is difficult to secure the durability of the angle joint and thus, it is difficult to reduce the thickness of the plate members forming the arm body 10.

Furthermore, in the case of the conventional boom, the upper lateral plate 13, the lower lateral plate 14 and the left and right vertical plates 15, 15 are formed by cutting them in accordance with the shape of the arm body

10, and the vehicle arm cylinder bracket 11 and the bucket-connection bracket 12 are welded to the arm body 10. Therefore, working of each of the plate members is complicated, the welding portion (welding line) is long, many steps are required to produce the boom and thus, the producing method is complicated.

A boom shown in Fig.5 in which one sheet of plate d is bent into U-shape and the upper lateral plate 13 and the left and right vertical plates 15, 15 are formed into one unit is known. However, in this case also, a step for cutting the plate d and the lower lateral plate 14, a step for bending, and a step for welding two welding portions (welding lines) are required and thus, many steps are required and this method is complicated.

Thereupon, it is an object of the present invention to provide a structure for a working machine of a bucket type excavator capable of solving the above problem, and a producing method of an arm of the bucket type excavator and the structure for the working machine of the bucket type excavator.

DISCLOSURE OF THE INVENTION

An arm of a bucket type excavator of a first invention is a structure for a working machine such as an arm of a bucket type excavator such as a hydraulic shovel, the arm body 22 has a cross section in which three sides are straight, and each of connected portions of the two sides is of arc shape.

According to the first invention, since the boom body 22 is triangular in cross section, due to characteristics of a triangle that its cross section is less prone to be deformed in the outward direction of surface by load, the boom body 22 can keep its cross section shape and secure the rigidity without using a cross section restraint material such as a pipe. Therefore, the plate thickness of the boom body 22 can be reduced to reduce its weight, and the cross section restraint material such as partition wall and the pipe is unnecessary and thus, its structure is simple, and the number of portions requiring welding is small and therefore, the durability and productivity are enhanced. Therefore, according to the first invention, the weight of the boom can largely be reduced, and the durability and productivity of the boom are excellent.

In a structure of a working machine of a bucket type excavator of a second invention, the arm body 22 has a cross section in which three sides are straight, and each

of connected portions of the two sides is of arc shape.

According to the second invention, since the cross section of the structure body 22 in which three sides are straight, and each of connected portions of the two sides is of arc shape, the sectional area can be increased such that it inscribes a sectional area a conventional structure, the cross section performance can be maintained, and since the angle portion is arc in shape, the stress can be dispersed. Therefore, according to the second invention, a large sectional area can be secured, the cross section performance can be maintained, and the rigidity of the boom can be enhanced.

In an arm of a bucket type excavator according to a third invention, a bucket thereof is mounted to a tip end side and pivotally supported by a boom, wherein the arm body 22 is hollow and triangular in cross section.

According to the third invention, since the arm body 22 is triangular in cross section, due to characteristics of a triangle that its cross section is less prone to be deformed in the outward direction of surface by load, the arm body 22 can keep its cross section shape and secure the rigidity without using a cross section restraint material such as a pipe. Therefore, the plate thickness of the arm body 22 can be reduced to reduce its weight, and the cross section restraint material such as partition wall and the pipe is unnecessary and thus, its structure is simple, and the number of portions requiring welding is small and therefore, the durability and productivity are enhanced. Therefore, according to the third invention, the weight of the boom can largely be reduced, and the durability and productivity of the boom are excellent.

In an arm of a bucket type excavator according to a fourth invention, the arm body 22 has a cross section of the third invention in which three sides are straight, and each of connected portions of the two sides is of arc shape.

According to the fourth invention, since the cross section of the arm body 22 in which three sides are straight, and each of connected portions of the two sides is of arc shape, the sectional area can be increased such that it inscribes a sectional area a conventional boom, the cross section performance can be maintained, and since the angle portion is arc in shape, the stress can be dispersed. Therefore, according to the fourth invention, a large sectional area can be secured, the cross section performance can be maintained, and the rigidity of the boom can be enhanced.

In an arm of a bucket type excavator according to a fifth invention, the arm body has a substantially triangle cross section of the fourth invention in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and a boom-mounting bracket 26 is jointed to a longitudinally lower surface.

As in the fifth invention, when the boom-mounting bracket 26 to be mounted to the boom is mounted to the lower surface of the arm body 22, if a lateral load (F2 in Fig.1) or a torsion load (F3 in Fig.1) is applied to the arm tip end, since the lower surface side is closer to the bracket 26 than the upper surface side, there is a tendency that a burden of a load of the lower surface side which is shorter in length is greater. Therefore, as in the fifth invention, if the lower surface is formed into a base of the triangle, the cross section performance can be exhibited more efficiently as compared with a structure which is turned upside down, and the weight can further be reduced. Further, also when the vertical load (F1 in Fig.1) is applied to such a boom, if the lower surface is the bottom surface of the triangle, the cross section performance can be exhibited more efficiently.

In an arm of a bucket type excavator according to a sixth invention, in the cross section of the fifth invention, a bucket cylinder bracket 25 is jointed to an upper surface of the arc connected portion of the two sides.

According to the sixth invention, since the top of the arm body 22 has great rigidity, even if the plate thickness of the mounting portion of the bucket cylinder bracket 25 is thin, the boom is not deformed. With this structure, the plate thickness of the mounting portion of the bucket cylinder bracket 25 of the arm body 22 can be thin to further reduce the weight of the boom.

In an arm of a bucket type excavator according to a seventh invention, in the cross section shape of the fifth invention, the arm body 22 has a substantially triangle cross section in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and a bucket cylinder bracket 25 is jointed to the flat portion of the top.

According to the seventh invention, since the top of the arm body 22 is the flat portion, when the bucket cylinder bracket 25 is welded to the flat top, edge preparation of the bucket cylinder bracket 25 is unnecessary and the throat depth of the weld joint can be

secured by using a fillet weld joint as the weld joint. Therefore, the welding operation of the bucket cylinder bracket 25 to the top of the arm body 22 is facilitated, and even if the plate thickness is thin, the welding strength can be maintained.

In an arm of a bucket type excavator according to an eighth invention, in the sixth or seventh invention, the bucket-connection bracket 23 is jointed to longitudinally one end of the arm body 22, and the arm cylinder bracket 24 is jointed to longitudinally other end of the arm body 22.

According to the eighth invention, the arm is suitable for carrying out the invention.

A producing method of a structure for a working machine of a bucket type excavator of a ninth invention, the method comprises the steps of: bending a plate material 73 having two long sides 70, 70 and two short sides 71, 71, thereby forming a hollow member which is triangular in cross section, and welding butted portions of the two long sides 70, 70, thereby forming a body 22.

According to the ninth invention, since one sheet of plate material is bent and the butted portions are welded to form the structure body 22, the working of the plate material is easy, and the welding portions (welding line) is short. With this method, the producing steps of the structure for the working machine are easy, the structure can be produced easily.

A producing method of a structure for a working machine of a bucket type excavator of a tenth invention, in the ninth invention, the body 22 has a cross section in which three sides are straight, and each of connected portions of the two sides is of arc shape, the body 22 has a triangle cross section in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and butt-welded portions of the two long sides 70, 70 are disposed on the lower surface.

According to the tenth invention, because the welding portion is disposed on the lower surface, there is a merit that the outward appearance is enhanced in addition to merits which can be obtained by the boom of the first to third inventions.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a perspective view of a power shovel;

Fig.2 is a front view of a conventional arm;

Fig.3 is a sectional view taken along the line A-A in Fig.2;

Fig.4 is an explanatory view of deformation of a cross section of the arm;

Fig.5 is a sectional view showing another example of the arm;

Fig.6 is a front view of a arm of an embodiment of the present invention:

Fig.7 is a plan view of the arm of the embodiment of the present invention:

Fig.8 is a sectional view taken along the line B-B in Fig.6;

Fig.9 is a sectional view taken along the line C-C in Fig.6;

Fig.10 is an exploded perspective view of the arm;

Fig.11 is a sectional view taken along the line D-D in Fig.6;

Fig.12 is a sectional view taken along the line E-E in Fig.6;

Fig.13 is a sectional view taken along the line F-F in Fig.6;

Fig.14 is a bottom view of an end of the arm;

Fig.15 is a sectional view taken along the line G-G in Fig.14;

Fig.16 is a sectional view taken along the line H-H in Fig.14;

Fig.17 is a sectional view taken along the line I-I in Fig.6;

Fig.18 is an explanatory view of a deformation of a cross section of the arm;

Fig.19 is an explanatory view of a size of the cross section of the arm;

Fig.20 is a plan view of a plate material for producing a main arm;

Fig.21 is a sectional view taken along the line J-J in Fig.20;

Fig.22 is an explanatory view of bending operation of the plate material;

Fig.23 is a perspective view of the bent plate material;

Fig.24 is an explanatory view of bending operation of the plate material;

Fig.25 is a perspective view of the bent plate material;

Fig.26 is an explanatory view of bending and jointing operations of the plate material;

Fig.27 is a perspective view showing jointed plate material;

Fig.28 is an explanatory view showing another

example of the arm body;

Fig.29 is an explanatory view showing another example of the arm body;

Fig.30 is an explanatory view of bending operation of a top cross member;

Fig.31 is an explanatory view of bending operation of a bottom side cross member;

Fig.32 is an explanatory view of back wave welding operation of one end of both members by a butt jig;

Fig.33 is an explanatory view of back wave welding operation of the other end of both members by a butt jig;

Fig.34 is a sectional view showing a different triangle shape of the boom front member and the boom rear member; and

Fig.35 is a sectional view showing another triangle shape of the boom front member and the boom rear member.

BEST MODE FOR CARRYING OUT THE INVENTION

As shown in Figs.6 and 7, an arm body 22 comprises a main arm body member 20 and an auxiliary member 21, a bucket-connection bracket 23 is jointed to longitudinally one end of the arm body 22, an arm cylinder bracket 24 is jointed to longitudinally other end of the arm body 22, a bucket cylinder bracket 25 is jointed to an upper surface of the arm body 22, a boom-mounting bracket 26 is jointed to a longitudinally intermediate lower portion of the arm body 22, thereby forming an arm 4.

An upper surface 22a of the arm body 22 is straight, a lower surface 22b is of substantially V-shape which is bent at the longitudinally intermediate portion (connected portion of the boom-connection bracket 26), longitudinally opposite ends of the arm body 22 are tapered in the height direction from the longitudinally intermediate portion. Longitudinally opposite ends of the arm body 22 are also tapered in the width direction from the longitudinally intermediate portion.

That is, in the arm body 22, the longitudinally intermediate portion has the greatest cross section, and a cross section of the arm body 22 is gradually reduced toward the longitudinally opposite ends.

As shown in Figs.8 and 9, the arm body 22 is hollow and triangular in cross section, a base side of the triangle is the lower surface 22b, and a top of the triangle is the upper surface 22a. A longitudinally intermediate portion of the lower surface 22b of the arm body 22 is formed with arc notch 27, and the boom-connection bracket 26 is jointed to the notch 27.

More specifically, as shown in Fig.8, a portion of the arm closer to a front end thereof than the longitudinally intermediate portion is only the main arm body member 20 and triangular in cross section. A portion of the arm closer to the rear end thereof than the longitudinally intermediate portion is the main arm body member 20 and the auxiliary member 21 and triangular in cross section, as shown in Fig. 9.

The arm body 22 is of isosceles triangle whose height H is greater than its width W, its three sides are straight, connected portions e, f, g of two sides are arc in shape, a curvature of the upper connected portion e is greater than those of the lower connected portions f and g. With this structure, stress applied to each of the connected portions is dispersed, a cross section performance required for a beam is secured, and vertical rigidity of the arm body is enhanced.

As shown in Figs.8 and 10, in the arm body member 20, one sheet of plate material 30 which is obtained by cutting a steel plate into a predetermined shaft is bent, portions thereof closer to the front end than the longitudinally intermediate portion are butt-welded, the front portion is triangular in cross section, and the rear portion is angle shape whose lower surface is opened. A bottom side of the triangle is the lower surface 20a, and a top of the triangle is the upper surface 20b. The welded portion 31 is continuos with the base side of the triangle in the longitudinal direction.

Opposite sides vertical plate lower angled portions closer to the rear end of the main arm member 20 are formed with arc recesses 32.

As shown in Fig.10, the auxiliary member 21 is obtained by cutting a steel plate 33 into a predetermined shape, and is formed into substantially C-shape having a lateral plate 21a and a pair of vertical pieces 21b, 21b, and the lateral plate 21a is formed with a notch 34.

As shown in Fig.9, the pair of vertical pieces 21b, 21b of the auxiliary member 21 are welded to the opposite sides vertical plates closer to the rear end of the main arm body member 20 through a backing plate 35, and formed triangular in cross section.

As shown in Fig.10, the bucket-connection bracket 23 is hollow and triangular in cross section, a front end thereof is formed with a pin insertion hole 40, an intermediate opposite side surface of the bucket 23 is formed with a pin engaging hole 41, and a rear end of the bucket 42 is integrally provided with a triangular

connection projection.

As shown in Fig.11, in the main arm body member 20 and the bucket-connection bracket 23, longitudinally one end opening edge of the main arm body member 20 (arm body 22) is fitted to a connection projection 42 of the bucket-connection bracket 23 to form a welding groove 43, and this portion is welded. A longitudinally one end edge 20c of the main arm body member 20 is thicker than other portion 20d so that throat thickness of the weld-joint can be secured to obtain sufficient welding depth and welding can be carried out strongly. With this structure, even if the plate thickness of the main arm body member 20 is reduced to reduce its weight, the bucket-connection bracket 23 can be welded strongly.

As shown in Fig.10, the bucket cylinder bracket 25 is of U-shape in which a pair of vertical pieces 44, 44 are connected with a lateral piece 45, the pair of vertical pieces 44, 44 are welded to the arc upper surface 22a of the arm body 22 as shown in Fig.12. With this structure, the rigidity of the mounting portion of the bucket cylinder bracket 25 of the arm body 22 can be secure, and even if the plate thickness of this portion is thin, it is not deformed by the reaction force of the bucket cylinder.

As shown in Fig.10, the arm cylinder bracket 24 includes a mounting portion 50 of the same triangle shape as the longitudinally other end edge of the arm body 22, a lateral plate 51 which is integrally formed with a lower portion of the mounting portion 50, and a pair of vertical pieces 52, 52 integrally provided between the mounting portion 50 and the lateral plate 51.

The mounting portion 50 is integrally provided a substantially triangular connection projection 53, the lateral plate 51 is integrally provided with a substantially U-shaped connection projection 54 which is formed with the connection projection 53 continuously. As shown in Fig.13, the connection projection 53 is fitted to the longitudinally other end opening edge of the arm body 22 to form and weld a welding groove 55.

As shown in Figs.14, 15 and 16, the connection projection 54 of the lateral plate 51 is fitted to the notch 34 of the auxiliary member 21 to form and weld a welding groove 56.

As shown in Fig.10, the boom-mounting bracket 26 is formed into a hollow structure comprising a lower lateral piece 60, a pair of vertical pieces 61, 61 and an arc upper lateral piece 62. The pair of vertical pieces 61,

61 are formed with pin fitting holes 63. The pair of vertical pieces 61, 61 and the upper lateral piece 62 are arc in shape having the same curvature as that of the arc notch 27 of the arm body 22, and the upper lateral piece 62 is integrally provided with an arc connection projection 64. As shown in Fig.17, the connection projection 64 is fitted to the notch 27 of the arm body 22 to form and weld a welding groove 65.

As described above, the arm body 22 constituting the arm has the triangular cross section, unlike the rectangular cross section, an element which determines a deformation strength of a cross section is determined only by the rigidity in the inward direction of surface of each of sides of the triangle. For example, In Figs.8 and 9, when the base is fixed and the load F shown with the arrow is applied to the top, as schematically shown in Fig.18, a compressing force is applied to one side j connecting the base h and the top i with each other, and the side f is shrunk and deformed, and a tensile strength is applied to the other side k and the side k is extended and deformed, and no force in the outward direction of surfaces is applied to the two sides j and k. That is, since the rigidity (rigidity in the inward direction of the surface) against the tensile and compressing force of the sides j and k is greater than the bending force in the outward direction of the surface, the rigidity of cross section of the boom having the triangular cross section is greater than that of the boom having the rectangular cross section.

In the general formula of the material mechanics, in the case of the strength of the working machine, if the size of the cross section is increased, strength of cross section can be secured even if the cross section is rectangular or triangular. However, if deformation of the cross section is taken into consideration as described above, in the case of the rectangular cross section, the rigidity of the corner and the rigidity of the side in the outward direction of the surface are lowered in proportion to reduction of the plate thickness. Whereas, in the case of the triangular cross section, the rigidity is lowered in proportion to a reduction ratio of the plate thickness. Therefore, variation in rigidity of the cross section due to the reduction in plate thickness of a boom having a triangular cross section is smaller than that of a boom having a rectangular cross section.

For the above reason, if a boom has a triangular cross section, even if the plate thickness is reduced, it

is possible to remarkably reduce the deformation of the cross section as compared with the conventional structure having a rectangular cross section, and from this fact, it is possible to reduce the boom in weight.

Further, as shown in Figs.8 and 9, since the connected portions e, f, g of the two sides are arc triangular in cross section, the cross section of the boom can be increased and the sufficient cross section performance can be secure. That is, as shown with a phantom line in Fig.19, the cross section can be increased by inscribing the arc connected portions e, f, g with rectangular inner surfaces of a space (height and width of the cross section) limited by disposition of the working machine on a machine, visual recognition properties of an operator and the like.

Especially when the boom-mounting bracket 26 to be mounted to the boom is mounted to the lower surface of the arm body 22, if the lateral load (F2 in Fig.1) or the torsion load (F3 in Fig.1) is applied to a tip end of the arm, the lower surface side is closer to the bracket 26 than the upper surface side, there is a tendency that a burden of a load of the lower surface side which is shorter in length is greater. Therefore, as described above, if the lower surface is formed into a base of the triangle, the cross section performance can be exhibited more efficiently as compared with a structure which is turned upside down, and the weight can further be reduced. Further, also when the vertical load (F1 in Fig.1) is applied to such a boom, if the lower surface is the bottom surface of the triangle, the cross section performance can be exhibited more efficiently.

Next, a producing method of the main arm body member 20 will be explained.

As shown in Fig.20, a steel plate is cut into a substantially rectangular plate material 73 which is surrounded by two opposed long sides 70, 70, and two opposed short sides 71, 71, the long side 70 is formed substantially V-shaped at one side portion 70a and other side portion 70b, and is the shape that the other side portion 70b has the arc notch 72. The thickness of the plate material 73 is set such that opposite ends 73a of the short sides 71 are thicker than other portion 73b. More specifically, as shown in Fig.21, bar materials 75 having thick portions and thin portions at longitudinally one end of the plate 74 which is cut into the predetermined shape.

Next, as shown in Fig.22, using a dice 80 having two

arc surfaces 80a, 80a and a straight surface 80b connecting the arc surfaces 80a, 80a, and having an arc surface 80c of a large curvature located at the center of the straight surface 80b, and using a punch 81 having two arc surfaces 81a, 81a and a straight surface connecting the two arc surfaces 81a, 81a, the plate material 72 is bent into arc shape along bending lines A closer to the long sides of the plate material 72, thereby forming the plate material 72 into a substantially U-shape as shown in Fig.23.

Next, as shown in Fig.24, a center of the plate material 72 is bent into an arc shape along a bending line B using the dice 80 and another punch 82, thereby forming the plate material 72 into a substantially rhombus shape. Since the same dice is used in this manner, a deviation in position is not generated and thus, the bending working precision can be secured.

Next, as shown in Fig.26, the bend plate material 72 is set on a dice 83, a pair of punches 84, 84 are moved laterally and vertically, thereby bending the plate material 72 into a triangle shape, and the two long sides 70, 70 of the plate material 73 are butted as shown in Fig.27. While keeping this state, a welding torch 85 is moved along a space between the pair of punches 84 and 84 to weld the butted portion.

Since the plate 73 is bent and formed into the final shape and welded simultaneously in this manner, the butt precision of the welding portion can be secured.

As shown in Fig.28(a), (b), the main arm body member 20 (arm body 22) may be produced by bending two plate materials to form a top side member 87 and a bottom side member 88, and jointing both the members.

As shown in Fig.29(a), (b), the main arm body member 20 (arm body 22) may be produced by bending three plate materials to form three members 89, and jointing the three members 89.

When the main arm body member 20 is produced using two plate materials as shown in Figs.28(a), (b), one plate material 93 is bent to form a top side member 87 using a dice 91 having a recess 90 whose base portion is of arc and substantially V-shape, and a punch 92 having the same shape as that of the recess 90.

As shown in Fig.31, a dice 101 is formed using a stationary dice 95 having an arc surface 94, a movable dice 97 having an arc surface 94 and arc surface 96 which is continuously connected to the arc surface 94, a spring 98 for separating the movable dice 97 from the stationary

dice 95, a cushion pad 99, and a cushion pin 100 for pushing up the cushion pad 99. A punch 103 having an arc surface 102 which is the same as the continuous two arc surfaces 94 and 96 is provided with a cam 104 which moves the movable dice 97 against the spring 98. When the punch 103 is in an upper position, the cushion pad 99 is pushed up by the cushion pin 100 and is flush with an upper surface of the movable dice 97.

One plate material 105 is bent using the dice 101 and the punch 103, thereby forming a base side member 88. More specifically, the plate material 105 is placed on the movable dice 97 and the cushion pad 99, and the punch 103 is lowered. While sandwiching the plate material 105 between the punch 103 and the cushion pad 99, the punch 103 is lowered and the cushion pad 99 is lowered, and opposite ends of the plate material 105 is sequentially bent by an arc portion 94 of the stationary dice 95.

When the punch 103 is lowered to a predetermined position, the movable dice 97 is moved by the cam 104 against the spring 98, the plate material 105 is bent into a predetermined shape, thereby forming the base side member 97.

Using a butt-jig shown in Fig.32, the top side member 87 and the base side member 88 are butted and penetration-welded.

The butt-jig includes a body 111 having a V-shaped groove 110, a pair of side pushing pieces 112, 112 provided on left and right opposite sides of the V-shaped groove 110 of the body 111, a pair of first cylinders 113, 113 for moving the side pushing pieces 112, a pair of upper pushing pieces 114, 114 provided on upper opposite sides of the V-shaped groove 110 of the body 111, a pair of second cylinders 115, 115 for moving the upper pushing pieces 114, 114, and a backing material 116 provided along the V-shaped groove 110 and supported by a supporting shaft (not shown) provided on opposite ends of the body 111.

The backing material 116 includes a water-cooling jacket 117 which is opened at an upper surface of the backing material 116, and a lower supporting portion 118. A receiving plate 119 is mounted to an upper surface of the backing material 116 such as to cover an upper portion of the water-cooling jacket 117. Cooling water flows through the water-cooling jacket 117. A welding torch 120 is movably mounted to an upper portion of he V-shaped groove 110 of the body 111.

Next, the operation of the penetration-welding will

be explained. As described above, the bent top side member 87 and base side member 88 are butted into a triangular shape and inserted between the V-shaped groove 110 and the backing material 116.

Each of the side pushing pieces 112 are moved toward the center, each of the upper pushing pieces 114 is moved downward, and one end 87a of the top side member 87 and one end 88a of the base side member 88 are butted on an upper surface of the receiving plate 119. The welding torch 120 is moved, thereby penetration-welding the butted portion.

Each of the side pushing pieces 112 is moved sideway, each of the upper pushing pieces 114 is moved upward, thereby separating these members, the top side member 87 and the base side member 87 to which the one ends 87a and 88a are welded are pulled out between the V-shaped groove 110 and the backing material 116.

The pulled out top side member 87 and base side member 88 are rotated, and again inserted between the V-shaped groove 110 and the backing material 116 as shown in Fig.33, and the other ends 87b and 88b are penetration-welded in the same manner as that described above.

With the above operation, the main arm body member 20 (arm body 22) comprising two members can be produced.

Further, as shown in Fig.29(a), (b), when the boom member is produced using three plate materials, one plate material is bent using the dice 91 and the punch 92 shown in Fig.30, thereby producing three members 89, and the three members 89 are sequentially penetration-welded at three points using the butt-jig shown in Fig.32, thereby producing the boom member.

Further, as shown in Figs.34(a) and (b), the arm body 22 may be formed such that upper connected portions e are formed by two arc portions X, Y, a flat portion Y and two arc portions Z-1 having small curvature, and an arc portion Z-2 having large curvature.

Although it is not illustrated, all of the three connected portion, or one of them or two of them may be formed into the above-described shape, or each of the connected portions may have different combination of shape.

If the boom has the flat portion Y shown in Fig.34(a), since the bucket cylinder bracket 25 can be welded to the flat portion Y. Therefore, edge preparation of the bucket cylinder bracket 25 is unnecessary and the throat depth of the weld joint can be secured by using a fillet weld joint as the weld joint.

As shown in Fig.35, the arm body 22 (the main arm body member 20) may have three sides which bulge with large curvature R instead of three straight sides. Alternately, the three sides may be a combination of bulged side and straight side.

The weld joint and the like are explained on the precondition that MAG (Metal ActiveGas) welding method or MIG (Metal InertGas) welding method is used, but it is possible to use high energy welding such as laser welding and electron beam welding by changing the weld joint. When a high energy density heat source is used, the thick portions provided on the opening edges 20c of the boom front member 20 may be omitted so that these portions have the same thickness as that of the other portions 20b the connection projections 42, 53, 54, 55, 56 and 64 may be omitted, and these portion may be butted and penetration-welded.

The embodiments are described above while taking the case of the hydraulic shovel, the present invention can also be applied to a bucket type excavator having different design and to a structure for a working machine other than arm in substantially the same manner.

CLAIMS

1. A structure for a working machine such as an arm of a bucket type excavator such as a hydraulic shovel, wherein a body (22) is hollow and triangular in cross section.

2. An arm of a bucket type excavator according to claim 1, wherein the arm body (22) has a cross section in which three sides are straight, and each of connected portions of the two sides is of arc shape.

3. A boom of a bucket type excavator whose bucket is mounted to a tip end side and pivotally supported by a boom, wherein the arm body (22) is hollow and triangular in cross section.

4. An arm of a bucket type excavator according to claim 3, wherein the arm body (22) has a cross section in which three sides are straight, and each of connected portions of the two sides is of arc shape.

5. An arm of a bucket type excavator according to claim 4, wherein the arm body (22) has a substantially triangle cross section in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and a boom-mounting bracket (26) is jointed to a longitudinally lower surface.

6. An arm of a bucket type excavator according to claim 5, wherein a bucket cylinder bracket (25) is jointed to an upper surface of the arc connected portion of the two sides.

7. An arm of a bucket type excavator according to claim 5, wherein the arm body (22) has a substantially triangle cross section in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and a bucket cylinder bracket (25) is jointed to the flat portion of the top.

8. An arm of a bucket type excavator according to claim 6 or 7, wherein the bucket-connection bracket (23) is jointed to longitudinally one end of the arm body (22), and the arm cylinder bracket (24) is jointed to longitudinally other end of the arm body (22).

9. A producing method of a structure for a working machine of a bucket type excavator comprising the steps of: bending a plate material (73) having two long sides (70), (70) and two short sides (71), (71), thereby forming a hollow member which is triangular in cross section, and welding butted portions of the two long sides (70), (70), thereby forming a body (22).

10. A producing method of a structure for a working machine of a bucket type excavator according to claim 8,

wherein the body (22) has a cross section in which three sides are straight, and each of connected portions of the two sides is of arc shape, the body (22) has a triangle cross section in which a lower surface thereof is a triangular base side, an upper surface thereof is a tip of the triangle, and butt-welded portions of the two long sides are disposed on the lower surface.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/03182

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^6 E02F3/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^6 E02F3/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-1998
Kokai Jitsuyo Shinan Koho	1971-1998	Jitsuyo Shinan Toroku Koho	1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 9-165773, Y (Komatsu Ltd.), 24 June, 1997 (24. 06. 97) (Family: none)	1-10
A	JP, 62-137327, Y (Sumitomo Heavy Industries, Ltd.), 20 June, 1987 (20. 06. 87) (Family: none)	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search 11 November, 1998 (11. 11. 98)	Date of mailing of the international search report 24 November, 1998 (24. 11. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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01-659

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